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Authors' Affiliation:

¹Dental Intern, College of Dentistry, Jazan University, Jazan, Saudi Arabia

²Al-Shifa College for Technical and Medical Science, Al Hodaydah, Yemen

³Department of Prosthetic Dental Science, College of Dentistry, Jazan University, Jazan, 45142, Saudi Arabia

*Corresponding Author

Department of Prosthetic Dental Science, College of Dentistry, Jazan University, Jazan, 45142, Saudi Arabia
Email: malmoleem@jazanu.edu.sa

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Using milled Polyetheretherketone Removable Dental Prostheses to treat a medically compromised patient

Abdulaziz Yahya Thubab¹, Mohammed J Abu Illah²,
Atheer Hassan Khawaji¹, Hafiz Hadi Harbi¹, Yahya
Qasem Tawhari¹, The-Anoon Abdo Baggash²,
Mohammed M Al Moaleem^{3*}

ABSTRACT

Polyetheretherketone (PEEK) is a promising material in the field of removable dental prostheses (RDPs) because of its unique properties and benefits. This case report presents the successful clinical application of milled PEEK in the fabrication of RDPs to the restoration of function and aesthetics in a 61-year medically compromised patient. Milled PEEK is a suitable alternative material because its appearance, durability, accuracy, aesthetics, biocompatibility, and other mechanical properties are superior to those of printed, injectable, and cast RDPs. The fabrication process included recording the patient's oral cavity, using computer-aided design, and milling. The RDPs were carefully adjusted and delivered to the patient. The patient reported a high level of satisfaction with this type of prosthesis, improved comfort, and enhanced chewing efficiency after a short period of follow-up. Therefore, the prepared milled PEEK is a valuable and potential material.

Keywords: Polyetheretherketone (PEEK), removable dental prostheses, medically compromised, computer-aided design/computer-aided manufacturing (CAD/CAM)

1. INTRODUCTION

Acrylic and cast RDPs are traditional types of dentures composed of acrylic alone or a combination of acrylic and metallic alloy framework, and cobalt-chromium (CoCr) is the most commonly used alloy (Curinga et al., 2023). They are designed to restore function and aesthetics by replacing missing teeth. However, this type of denture has drawbacks, including unappealing metallic appearance due to the framework, heavy weight, and visible clamps and supports (Carr et al., 2004). PEEK is an alternative to RDPs, has different

types (milled, printed, and injected), and has advantages over metal-based options (Ichikawa et al., 2019; Harb et al., 2019). It has excellent mechanical properties, impressive resistance to heat, chemicals, and radiographic radiolucency. Additionally, PEEK can be operated to eliminate the unpopular silver color and the allergic reactions often associated with metal prostheses or from monomer of acrylic dentures (Saeed et al., 2020).

Incorporating CAD/CAM into the creation of dental prostheses, it increased efficiency by saving materials, time, effort, possibility of mass production, and further streamlining the process (Hu et al., 2019). PEEK presents high biocompatibility, good mechanical properties, high temperature resistance, and chemical stability (Tannous et al., 2012). Many aged patients are diagnosed with some medical condition before they undergo prosthodontic treatment. These therapies are often delayed until the medical conditions are evaluated. Drugs taken by patients for their systemic conditions should be known because drugs affect treatment outcomes and interact with one another. Systemic evaluation and physician consultation should be an integral part of prosthodontic treatment plan (Lo-Russo et al., 2023).

In some clinical settings, PEEK is often preferred as a cosmetic and alternative to CoCr for RDP because it provides a precise as well as acceptable discrepancy, and well-fitting framework (Harb et al., 2019; Carneiro-Pereira et al., 2021; Jovanović et al., 2021). The fit of a PEEK clasp retainer for the mandibular bilateral distal free-end abutment showed no deformation after 2 years of follow-up, no occlusal or periodontal problems were observed, and subjective satisfaction was expressed by the practitioner and the patient (Ichikawa et al., 2019). Two approaches are used in processing PEEK in RDPs. One involves milling a prosthesis from CAD/CAM blocks, and the other implicates using vacuum heat pressing with granules or pellets (Punia et al., 2022).

Both are made through 3D printing. This form of additive manufacturing enables the production of highly precise final products and offers the opportunity to fabricate complex designs (Moharil et al., 2023). Milling PEEK can be considered the best fabrication method because it provides a homogenous microlayer and higher flexural strength than the printing and injection method (Skariah et al., 2022). The main goal of this report is to document a clinical case of a medically compromised patient in which a digital workflow was used in creating an RDP framework by milling PEEK as the prosthetic material. The study evaluated patient satisfaction, comfort, retention, and masticatory performance.

2. CASE REPORT

A 61-year-old Eritrean male patient was referred to comprehensive care clinics for a prosthodontic evaluation and treatment from intern clinics in the College of Dentistry, and Jazan University. His primary complaint was "I want to eat food properly". The patient's medical problems were hypertension, history of stroke (4 years ago), central post stroke syndrome, and vitamin D deficiency. He is under medication in relation to his medical problems (Aspirin, Vitamin D, Gabapentin, and Sevikar). He had undergone multiple extractions over a long period, FDP 5 years ago, and multiple restoration was conducted in the posterior teeth. He had visited dentists regularly and brushed his teeth with a hard brush but not on a regular daily basis but uses Miswak two times a day. Extraoral and Intraoral examination of the palate, mouth floor, tongue, buccal mucosa, and oropharynx showed symmetry and no abnormalities.

The maxillary arch was U-shaped. Existing gingival caries in relation to teeth #11 and #21 amalgam restoration on tooth #16, and composite restoration for tooth #14 and multiple remaining roots in both sides, localized gingival inflammation, and generalized wear facets were noted (Figure 1A). The mandibular arch was U-shaped with missing bilateral anterior and posterior teeth. Previous abutment preparations were detected on teeth #34, #35, #43, and #44. The periodontal finding showed poor oral hygiene and recession on all existing teeth, especially in the anterior region (Figure 1B). Patient had no canine, molar relationship, and anterior guidance because of missing lower anterior teeth. Moreover, he had no contact in excursive movements, indicating poor neuromuscular coordination because of a minimal proprioception impulse (Figure 1C–E).

The periapical radiographs showed that the maxillary and mandibular teeth were partially dentate with generalized chronic moderate periodontitis. Multiple missing teeth and remaining roots were observed in the posterior area in both arches, and defective restoration because root canal treatment (RCT) of tooth #16 and dental or secondary on caries were observed in several teeth. The pretreatment panoramic radiograph showed a finely woven and dense trabecular bone pattern, severe horizontal bone loss was detected, especially in the posterior area at the molar areas (Figure 2). Abutments in both arches exhibited an insufficient tooth structure and required adjunctive therapy, that is, periodontal and/or RCT procedures or both. The re-establishment of the total occlusal scheme was essential because the vertical dimension of occlusion (VDO) improved by 2 mm.

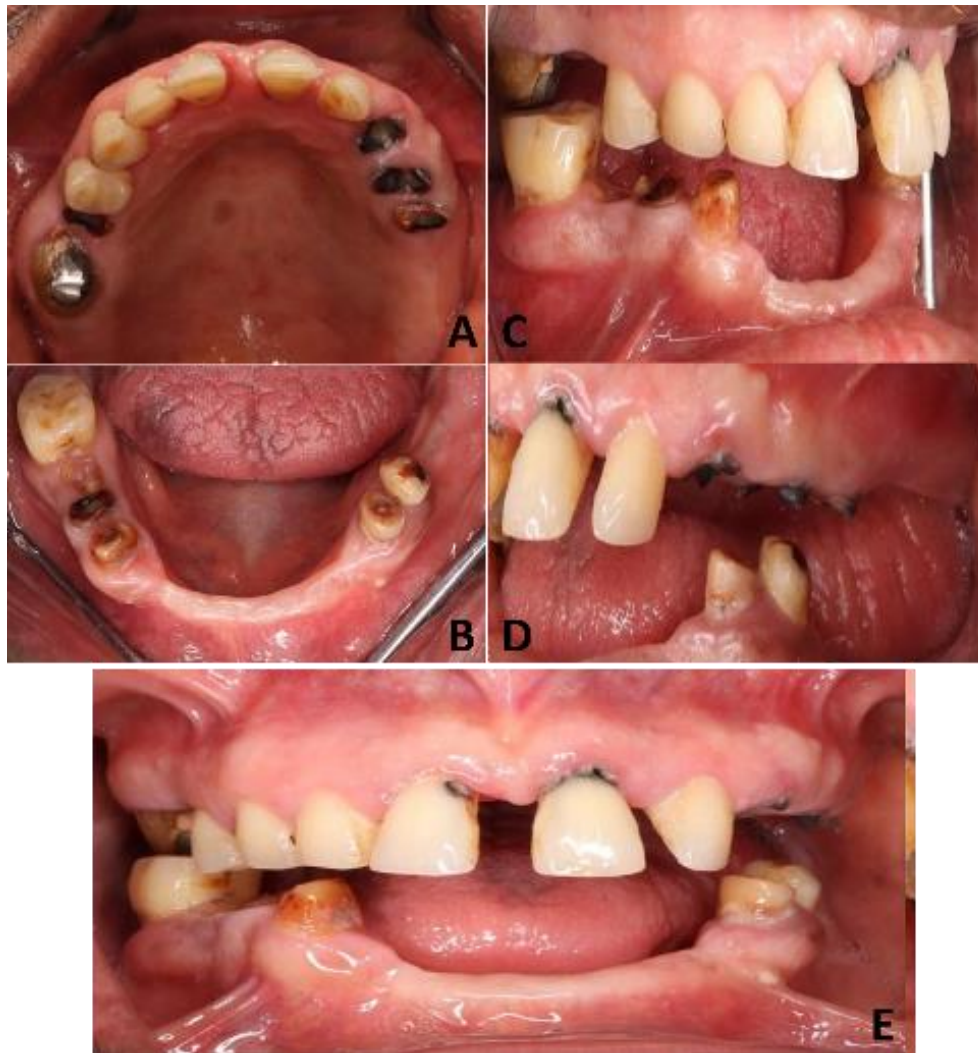


Figure 1A to E Preoperative intraoral view

A medical clearance report indicating his medical fitness for dental procedures was obtained from a cardiologist. It indicated that dental treatments can be performed according to the treatment plan, but precautions should be taken before any dental procedure and administration of medication. Related protocols were used during dental treatments (Mahmoudi et al., 2023). A diagnostic cast was made using irreversible hydrocolloid and dental stone. The face-bow transfer was utilized to mount the maxillary cast and verified using the split cast technique. Occlusion analysis revealed an insignificant discrepancy between the centric occlusion and maximum intercuspation at the existing VDO. After the clinical and radiographical examinations and interpretation of the collected data, the casts were mounted on a semi adjustable articulator (Bioart A7 Plus-E with elite facebow). A full diagnostic wax-up was retrieved at the new OVD. Appropriate occlusal planes and scheme were reestablished (Figures 3C–E).

The treatment plan followed the phases suggested by Rosenstiel et al., (2022) was explained to the patient. Before treatment was ongoing and in phase I, an emergency RCT treatment was established in relation to tooth #34. Then, a multidisciplinary consultation was conducted. Deep scaling with root planning for the remaining teeth was performed, and the patient was instructed for oral hygiene measures. RCTs were performed in relation to teeth 35 and 43. In phase II, all defective restorations and remaining hopeless roots (teeth #16, #15, #23, #24, #25, #44, and #45) were extracted, and caries control was conducted on all remaining teeth. Extractions were performed as atraumatic as possible, and then Gelfoam placement in extraction as socket post extraction. Eight sutures were made to hold the hemostatic material in place, gauze biting was performed for 20 mins, and bleeding was evaluated. After achieving haemostasis, the patient was recalled for the next appointment after receiving postsurgical instructions (Ali et al., 2020).



Figure 2 Preoperative radiographs

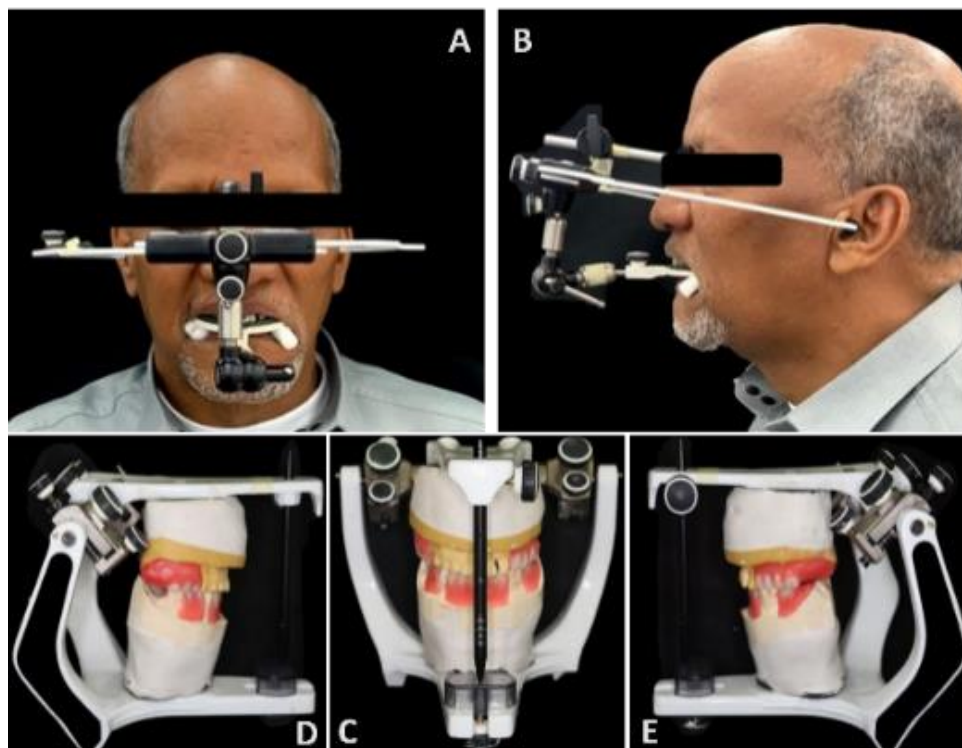


Figure 3 A-B during face-bow transfer, C-E mounting diagnostic casts with full-mouth diagnostic wax-up

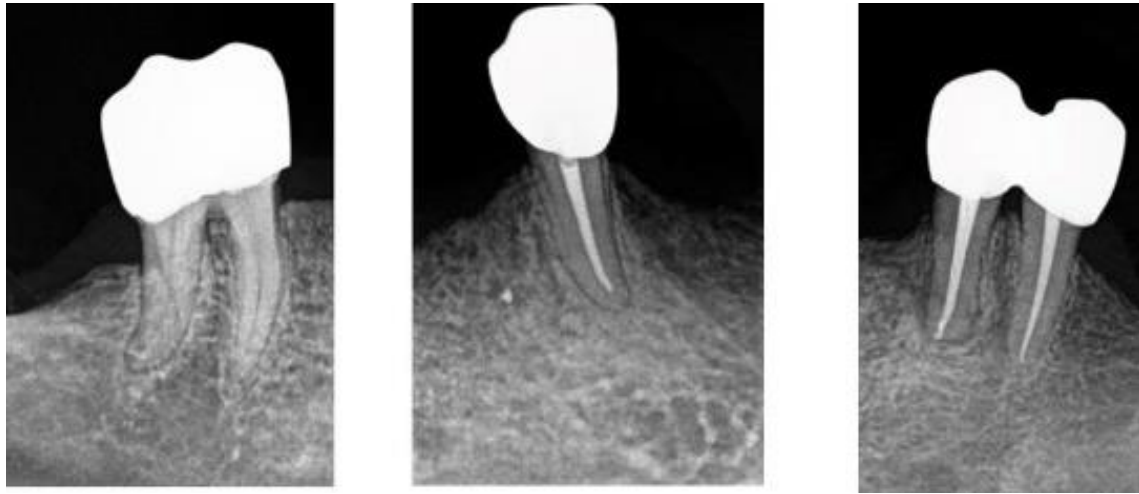


Figure 4 After root canal treatment and crowning of mandibular abutment teeth.

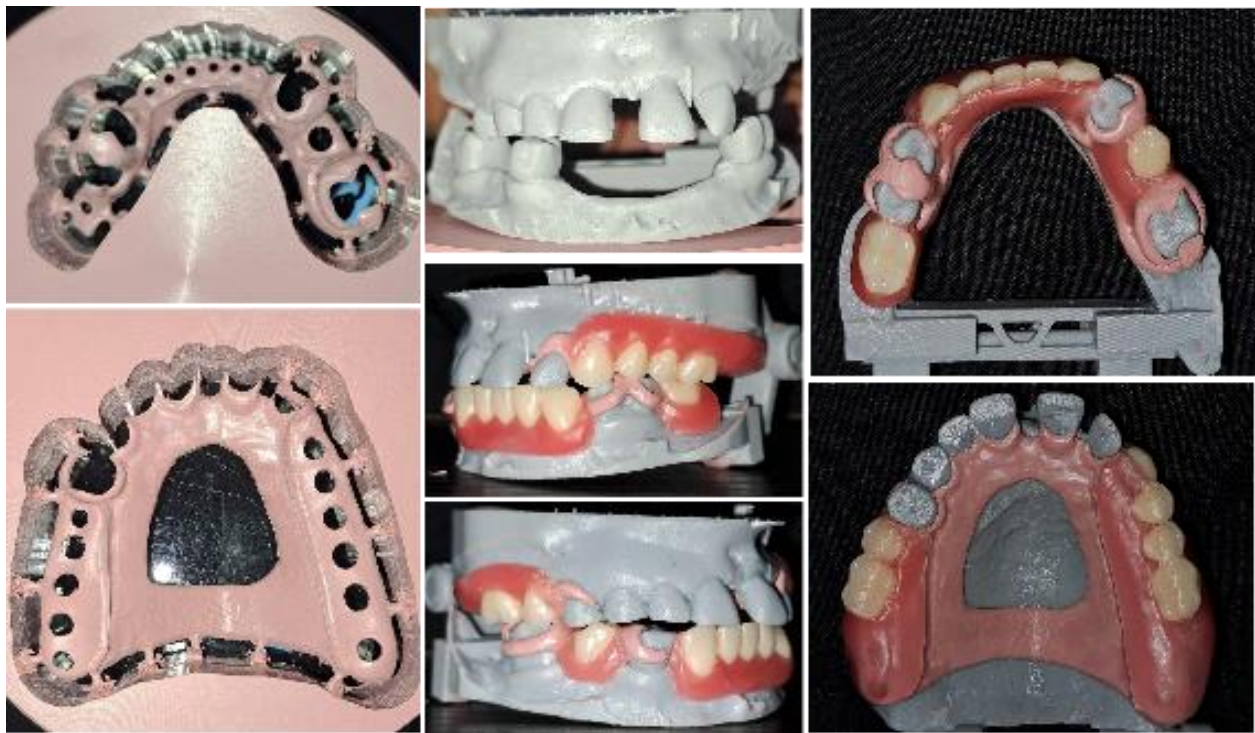


Figure 5 Different steps during construction of milled PEEK RDP

In phase III, composite restorations were performed. Subsequently, the RDPs were designed and started by the preparation of the RCT teeth that will receive surveyed metal crowns. The design included the occlusal rest and guide planes of the abutment, and final impressions were obtained by using an additional silicone polyvinyl siloxane impression material (Virtual, Ivoclar Vivadent, Lichtenstein). The crowns construction and cementation were used in a conventional manner (Figure 4). The RDPs were constructed as recommended Curinga et al., (2023), Ichikawa et al., (2019), Harb et al., (2019) with some modifications related to the different steps of RDP construction. The steps consisted of mouth preparation, designing and fabrication of framework for both arches (Figure 5). Then, the try-in and centric occlusion relationship registration, tooth selection, and or set-up, and insertions and occlusal and postoperative adjustment of PEEK RDP were carried out at the next appointment. Post-operative views of both arches milled PEEK RDPs are presented in (Figure 6A–E).

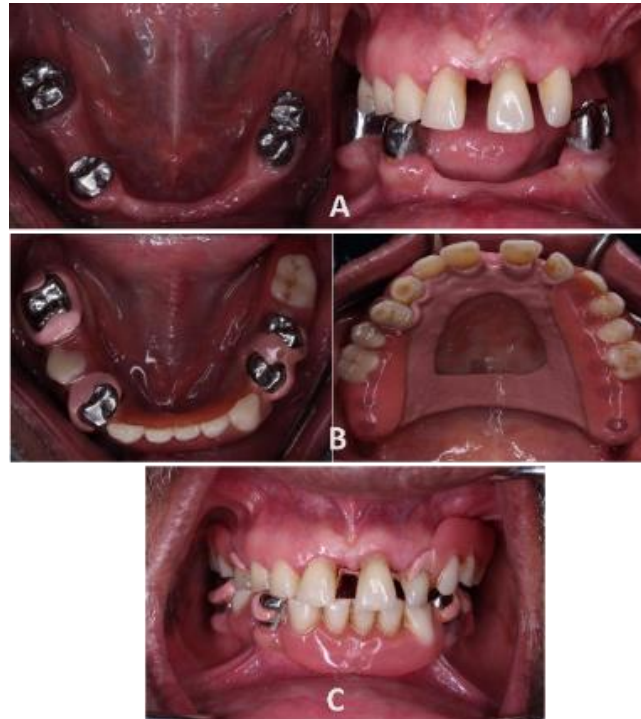


Figure 6 A: Arches with cemented crowns, B: Maxillary and mandibular PEEK RPD, C: Postoperative frontal view at maximum intercuspation of both arches

Phase IV was started by a recall after a week of the insertion of the prosthesis. Oral hygiene was then reevaluated, and prosthesis adjustments and post-treatments were made to accommodate lower labial frenum because traumatic ulcer was evident in that area because of the slight overextension of the mandibular PEEK RPD. The patient was placed on 6 months recalls, postoperative instructions were explained and reviewed with the patient, including daily routine. At this appointment, supportive periodontal therapy was carried out.

3. DISCUSSION

In the selection of a material for RDP construction, clinical assessment, patient preferences, and scientific evidence are crucial. CR-Co is widely utilized because of its affordability, impressive mechanical and physical attributes, and predictive qualities, which contribute to its popularity (Giachetti et al., 2020). Cr-Co has certain limitations in terms of aesthetics, particularly when the clasps are positioned in the anterior area. It causes discomfort and has negative effects on abutment teeth, clasps fractures, and microporosity because of material shrinkage during manufacturing (Moharil et al., 2023). Research aimed at minimizing the drawbacks associated with employing metal alloy in the fabrication of RDPs, highlighted PEEK as an excellent alternative that improves aesthetics and comfort (Giachetti et al., 2020). In this case, the patient selected such treatment because of financial issues and the other benefits of milled PEEK.

The existing virtual planning digital systems in dentistry that are available in the market can process data acquired through digital scans performed on plaster models or directly from the patient (Kihara et al., 2020). The greatest benefit of a digital impression is comfort to patients, and it eliminates any distress, particularly nausea (Vandenberghe et al., 2018). Owing to disadvantages associated with intraoral scanning systems, training in operating the systems is essential (Suese et al., 2020). The operating field should be free of gingival fluid and kept dry (Tasaka et al., 2020). In this report, the patient was old and medically compromised. Thus, to avoid any issue, we used the direct scanning method in scanning of both arches. Firstly, the low elastic modulus of PEEK warrants lighter RDPs and provides a reducing effect on occlusal forces (Saeed et al., 2020).

A recent systematic review concluded that PEEK RDPs produced by rapid prototyping exhibited good results in terms of the intraoral framework fitting (Jovanović et al., 2021). For this reason, an accurate reproduction of the dental condition is a must to enhance the fit of the prosthesis (Tasaka et al., 2020). Arnold et al., (2018) reported that milled-PEEK clasps had a significantly superior fit in both the vertical and horizontal orientations compared to the CoCr clasps. Furthermore, PEEK presents high biocompatibility, good mechanical properties, high temperature resistance, and chemical stability (Ichikawa et al., 2019; Harb et al., 2019; He et al., 2017). A randomized controlled trial study was conducted to assess and compare the satisfaction of patients who

wore metal and PEEK RPDs. The results showed that the patients were more satisfied with the milled PEEK framework than with the CoCr RPDs (Curinga et al., 2023; Ichikawa et al., 2019; Harb et al., 2019).

Patients express greater satisfaction with the aesthetics and appearance of PEEK clasps than with those of metal alloys (Negm et al., 2019). This result agrees with the present report; the patient was satisfied with his appearance and comfort. Another advantage of PEEK is clasp flexibility, which can benefit the abutment teeth because it engages undercuts around the healthy abutment. These clasps exert a horizontal force on the abutment teeth during the repeated cycles of insertion and removal. Unfortunately, this excessive stress can result in periodontal issues and subsequent resorption of the alveolar bone, particularly in the abutment teeth (Zoidis et al., 2016). According to a clinical report, the PEEK's clasp on the abutment teeth did not show any unusual movement, and no inflammation was observed in the gingiva surrounding the abutment teeth. Moreover, PEEK clasps are gentler on the enamel and restorative ceramic materials compared to traditional CoCr clasps (Chen et al., 2019).

The drawbacks of the PEEK clasp are its low modulus of elasticity (4 GPa), which is considerably lower than that of CoCr clasps (240 GPa) and increased flexibility. Thus, two issues were proposed: incorporating deep retentive areas (at least 0.5 mm) or increasing the bulkiness of the PEEK clasps when additional retention is needed (Negm et al., 2019; Chen et al., 2019). To overcome these drawbacks, we increased the thickness of the clasp and incorporated deep retentive areas. Given that the patient's medical and dental conditions were compromised, we implemented rehabilitation that can withstand forces exerted during chewing and biting without compromising its structural integrity. Milled PEEK has a low modulus of elasticity, which promotes the absorption and distribution of forces during occlusal loading, potentially reducing the strain on the PDL and minimizing excessive forces on the ligament and risk of damage to PDL.

4. CONCLUSION

This case report demonstrates the successful use of PEEK with a digital fabrication of an RDP framework for a medically compromised patient. The utilization of a digital workflow allowed precise and accurate manufacturing, resulting in a high level of patient satisfaction, comfort, and retention. Additionally, PEEK conferred excellent weight, taste, and masticatory performance and improved the overall quality of life of the patient. These findings highlighted the potential benefits of incorporating PEEK into the field of prosthodontics, offering a promising alternative to traditional materials in RDP fabrication.

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Author Contributions

All authors of this work contributed by treating the patient, data collection and writing the full manuscript.

Informed consent

Written and Oral informed consent was obtained from the patient.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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